

CIRCUITS AND METHODS PROVIDING TEMPERATURE MITIGATION FOR COMPUTING DEVICES USING IN-PACKAGE SENSOR

TECHNICAL FIELD

[0001] This application relates to thermal mitigation and, more specifically, to providing thermal mitigation to a computing device using an in-package and off-chip temperature sensor.

BACKGROUND

[0002] A conventional modern smart phone may include a system on chip (SOC), which has a processor and other operational circuits. Specifically, an SOC in a smart phone may include a processor chip within a package, where the package is mounted on a printed circuit board (PCB) internally to the phone. The phone includes an external housing and a display, such as a liquid crystal display (LCD). A human user when using the phone physically touches the external housing and the display.

[0003] As the SOC operates, it generates heat. In one example, the SOC within a smart phone may reach temperatures of 80° C.-100° C. Furthermore, conventional smart phones do not include fans to dissipate heat. During use, such as when a human user is watching a video on a smart phone, the SOC generates heat, and the heat is spread through the internal portions of the phone to the outside surface of the phone.

[0004] The outside surface of the phone is sometimes referred to as the “skin.” The outside surface includes the part of the external housing that is physically on the outside of the phone as well as any other externally-exposed portions, such as an LCD display. It is generally accepted that the skin of the phone should not reach temperatures higher than about 40° C.-45° C. due to safety and ergonomic reasons. As noted above, the SOC within the smart phone may reach temperatures of 80° C.-100° C., although the temperature of the SOC is not felt directly at the skin of the phone. Instead, heat dissipation within the phone often means that the skin temperature of the phone is at a lower temperature than the SOC temperature. Furthermore, whereas changes to SOC temperature may be relatively quick (e.g., seconds), changes to device skin temperature may be relatively slow (e.g., tens of seconds or minutes).

[0005] Conventional smart phones include algorithms to control the skin temperature by reducing a frequency of operation of the SOC when a temperature sensor in the SOC reaches a threshold level. However, SOC temperature can be a poor proxy for device skin temperature.

SUMMARY

[0006] Various embodiments include systems and methods that mitigate temperature by measuring temperature off-chip and in-package and reducing performance of a processor, if appropriate, based at least in part on the temperature measurement.

[0007] In one embodiment, a method includes receiving an electrical signal from a temperature sensor, wherein the temperature sensor is disposed within a package including a processor chip, further wherein the temperature sensor is thermally separated from the processor chip by materials within the package, generating temperature information

from the electrical signal, processing the temperature information to determine that a performance of the processor chip should be mitigated, and mitigating the performance of the processor chip in response to the temperature information, wherein processing the temperature information and mitigating the performance of the processor are performed by the processor chip.

[0008] In another embodiment, a system includes a computer processor configured to execute machine-readable instructions and to consume power from a system battery, the computer processor being disposed within a package having a dielectric substrate and providing electrical communication between the computer processor and a plurality of electrical components of the system, a physical housing enclosing at least a portion of the system, the package being disposed within the system so that it is enclosed within the physical housing, the computer processor further being in thermal contact with the physical housing through the package, and a temperature measuring device disposed within the package and thermally separated from the computer processor by materials of the package, the temperature measuring device being in electrical communication with the computer processor. The computer processor is configured to perform the following operation: receive electrical signals from the temperature measuring device, in response to the electrical signals from the temperature measuring device, determine that a thermal mitigation operation should be undertaken, and reduce an operating parameter of the computer processor in accordance with the thermal mitigation operation.

[0009] In another embodiment, a system includes means for providing information indicating a temperature of a chip package within the system, means for comparing the temperature of the chip package to a temperature threshold and for generating a control signal in response to determining that the temperature of the chip package exceeds the temperature threshold, means for reducing an operating parameter of the means for comparing in response to the control signal; and a physical housing enclosing at least the means for comparing and the means for providing, the means for comparing further being in thermal contact with the means for providing through a substrate of the chip package.

[0010] In yet another embodiment, a computer program product having a computer readable medium tangibly recording computer program logic for mitigating temperature of a chip, the computer program product includes code to generate temperature information from a sensor within a chip package and at a location physically separate from the chip within the chip package, code to compare the temperature information to a programmed temperature threshold, wherein comparing the temperature information to the programmed temperature threshold is performed by the chip, code to reduce an operating parameter of the chip in response to comparing the temperature information to the programmed temperature threshold, and code to increase the operating parameter of the chip in response to determining that the temperature information indicates a reduction in temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is an illustration of an example computing device that may perform a method according to various embodiments.